CLAIMS

1. An optical device, comprising:

a first Mach-Zehnder modulator that produces a first output;

a second Mach-Zehnder modulator that produces a second output;

a splitter coupled to the first and second Mach-Zehnder modulators;

a combiner that combines the first and second outputs; and

a phase shifter coupled to the first and second Mach-Zehnder modulators, wherein the first Mach-Zehnder modulator, the second Mach-Zehnder modulator, the splitter, the combiner and the phase shifter are formed as part of a single planar chip made of electro-optical material.

2. The optical device of claim 1, wherein the single planar chip is a single piece of crystal.

3. The optical device of claim 1, wherein the chip is made of a material selected from $LiNbO_3$ or $LiTaO_3$.

4 The optical device of claim 1, wherein the chip is made of $LiNbO_3$ or $LiTaO_3$ cut at X, or Y, or Z planes.

5. The optical device of claim 1, wherein the splitter is a Y-junction.

6. The optical device of claim 1, wherein the splitter is a waveguide coupler.

7. The optical device of claim 1, wherein the combiner is a Y-junction.

8. The optical device of claim 1, wherein the combiner is a waveguide coupler.

9. The optical device of claim 1, wherein the first Mach-Zehnder modulator includes a first biasing electrode, and the second Mach-Zehnder modulator includes a second biasing electrode.

10. The optical device of claim 1, further comprising:

a first bias electrode coupled to the first Mach-Zehnder modulator; and

a second bias electrode coupled to the second Mach-Zehnder modulator.

11. The optical device of claim 10, wherein each of the first and second bias electrode is a push-pull configuration.

12. The optical device of claim 10, wherein the first and second bias electrode are configured to optimize a DC bias point of the first and second Mach-Zehnder modulators

13. The optical device of claim 1, wherein the splitter is adjustable.

14. The optical device of claim 1, wherein the combiner is adjustable.

15. The optical device of claim 1, wherein each of the first and second Mach-Zehnder modulators is a push-pull configuration.

16. The optical device of claim 1, wherein the splitter is positioned at an input of the optical device, and the combiner is positioned at an output of the device.

17. The optical device of claim 1, wherein the splitter and combiner are 3-dB devices.

18. The optical device of claim 1, wherein each of the first and second Mach-Zehnder modulators is driven by an RF signal.

19. The optical device of claim 1, wherein the optical device includes at least a first and a second waveguide each associated with one of the first and second Mach-Zehnder modulators.

20. The optical device of claim 1, wherein the waveguides of the first and second Mach-Zehnder modulators are coplanar to each other.

21. The optical device of claim 1, further comprising:

a phase shifter with a third bias electrode coupled to each of the first and second Mach-Zehnder modulators and configured to provide an adjustable 90° phase difference between outputs from first and second Mach-Zehnder modulators.

22. The optical device of claim 21, wherein the phase shifter is a push-pull configuration.

23. The optical device of claim 1, wherein the splitter divides an input beam into substantially equal first and second beams that are directed to the first and second Mach-Zehnder modulators.

24. The optical device of claim 1, wherein each of the first and second Mach-Zehnder modulators are independently modulatable.

25. The optical device of claim 1, wherein the electro-optical material is a crystal made of a material selected from $LiNbO_3$ or $LiTaO_3$, with a cut at X, Y, or Z planes relatively to an axis of the crystal.

26. The optical device of claim 1, wherein indifussed metal technology is used with the electro-optical material includes.

27. The optical device of claim 1, wherein protonic-exchange optical technology is used with the electro-optical material includes.

28. The optical device of claim 1, wherein etching optical technology is used with the electro-optical material.

29. The optical device of claim 1, wherein milling optical technology is used with the electro-optical material.

30. The optical device of claim 1, wherein the electro-optical material includes a substrate coated with a buffer.

31. The optical device of claim 30, wherein the buffer is silicon dioxide.

32. An optical device, comprising:

a first Mach-Zehnder modulator that produces a first output;

a second Mach-Zehnder modulator that produces a second output;

a third Mach-Zehnder modulator that produces a third output;

a fourth Mach-Zehnder modulator that produces a fourth output;

a first input splitter coupled to the first and second Mach-Zehnder modulators;

a first phase shifter coupled to the first and second outputs;

a first output combiner positioned to combine the first and second outputs from the first and second Mach-Zehnder modulators;

a second input splitter coupled to the third and fourth Mach-Zehnder modulators;
a second phase shifter coupled to the third and fourth outputs; and
a second output combiner positioned to combine the third and fourth outputs.

33. The optical device of claim 32, wherein the first, second, third and fourth Mach-Zehnder modulators, the first and second input splitters, the first and second phase shifters, and the first and second input splitters are formed as part of a chip made of electro-optical material.

34. The optical device of claim 32, further comprising:
a third input splitter coupled to the first and second input splitters.

35. The optical device of claim 32, further comprising:
a third combiner coupled to the first and second combiners.

36. The optical device of claim 32, further comprising:
a polarization converter and combiner coupled to the first and second combiners.

37. The optical device of claim 33, wherein the third splitter and third combiner are formed as a part of the chip.

38. The optical device of claim 37, wherein the third splitter and third combiner are formed as a part of a second chip.

39. The optical device of claim 32, wherein the first, second, third and fourth Mach-Zehnder modulators, first and second splitters, first and second combiners are formed as a part of a chip made of an electro-optical material, and the first and second phase shifters, third splitter and third combiner are formed as a part of a second chip made of an electro-optical material.

40. The optical device of claim 34, wherein the third input splitter is a 3-dB device.

41. The optical device of claim 35, wherein the third combiner is a 3-dB device.

42. The optical device of claim 34, wherein the third input splitter is a Y-junction.

43. The optical device of claim 34, wherein the third input splitter is a waveguide coupler.

44. The optical device of claim 32, wherein the first output combiner is a Y-junction.

45. The optical device of claim 34, wherein the first output combiner is a waveguide coupler.

46. The optical device of claim 34, wherein the third input splitter is adjustable.

47. The optical device of claim 35, wherein the third combiner is adjustable.

48. The optical device of claim 34, where the third input splitter is polarization splitter.

49. A method of producing an optical output, comprising:

providing an optical device with first and second Mach-Zehnder modulators formed as part of a single planar chip made of electro-optical material;

producing a first output from the first Mach-Zehnder modulator:

producing a second output from the second Mach-Zehnder modulator; and

combining the first and second outputs to produce a combined output.

50. The method of claim 49, further comprising:

applying a bias voltage to each of the first and second Mach-Zehnder modulator to set a DC bias point.

51. The method of claim 49, further comprising:

maintaining the first and second Mach-Zehnder modulators at extinction points.

52. The method of claim 49, further comprising:

detecting an average optical power of the combined output.

53. The method of claim 52, further comprising:

minimizing the average optical power of the combined output.

54. The method of claim 49, further comprising:

detecting an average optical power of the first and second outputs.

55. The method of claim 54, further comprising:

minimizing the average optical power of each of the first and second outputs.

56. The method of claim 49, further comprising:

applying a signal to each of the first and second Mach-Zehnder modulators in respone to an average power of the combined output.

57. The method of claim 49, further comprising:

applying a signal to each of the first and second Mach-Zehnder modulators in respone to an average power of the first output and the second output respectively.

58. The method of claim 49, further comprising:

obtaining a 90° phase difference between the first and second Mach-Zehnder modulators.

59. The method of claim 49, further comprising:

detecting an optical power variation of the combined output.

60. The method of claim 59, further comprising:

minimizing the optical power variation of the combined output.

61. The method of claim 49, further comprising:

producing a signal in respond to a data-induced optical power variation of the combined output.

62. The method of claim 49, further comprising:

maintaining the same output power at each of a channel of the first and second Mach-Zehnder modulators.

63. The method of claim 62 further comprising:

equalizing the output power of each channel of the first and second Mach-Zehnder modulators separately.

64. The method of claim 63, further comprising:

amplitude modulating at least one of the channels; and

detecting a power of at modulating frequency.

65. The method of claim 49, further comprising:

obtaining a timing alignment between applied data signals and optical pulses.

66. The method of claim 49, further comprising:

detecting an average output power from at least one of the first or second Mach-Zehnder modulators; and

producing a signal proportional to an average output power for the average output power related to a timing alignment between applied data signals or an optical pulse and an applied data signal.

67. The method of claim 49, wherein the optical device includes a feedback control loop that produces a signal to maximize a voltage timing signal

68. The method of claim 49, wherein each of the first and second Mach-Zehnder modulators is driven by an RF signal.

69. A method for dual polarization transmission, comprising:

providing a device that includes a first optical device with first and second Mach-Zehnder modulators, and a second optical device with third and fourth Mach-Zehnder modulators, the first and second optical devices being formed as part of a single planar chip made of electro-optical material;

producing from the first optical device of a first output with a first polarization;

producing from the second optical device a second output with a second polarization;

combining the first and second outputs to produce a beam with two orthogonal polarization signals.